~~17~~ 34 Free fall in an elevator

A phone of mass m sits on the floor of an elevator, which is initially at rest. The elevator cable snaps and the elevator and phone then undergo free fall. While they do this which is true of the magnitude of the normal force, n, acting on the phone? Explain your choice.

i) $n = 0$.
ii) $mg > n > 0$.
iii) $n = mg$.
iv) $n > mg$

In free fall acceleration is

$$a_y = -g$$

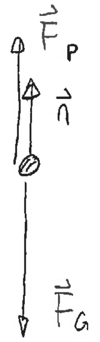
$$\sum F_{iy} = m a_y$$

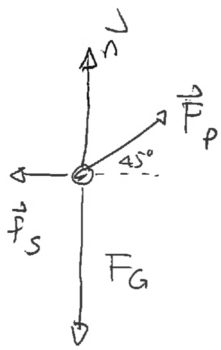
$$\Rightarrow \quad n - mg = m(-g)$$

$$\Rightarrow \quad n = 0$$

A

2016 Supp Ex 35





$\sum \vec{F} = m\vec{a} = 0$

$\Rightarrow F_p + n_A - F_G = 0$

$\Rightarrow n_A = F_G - F_p$ ✓

$\sum \vec{F} = m\vec{a} = 0 \Rightarrow \sum F_y = ma_y = 0$

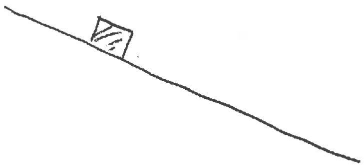
$\Rightarrow n_B + F_p \sin 45° - F_G = 0$

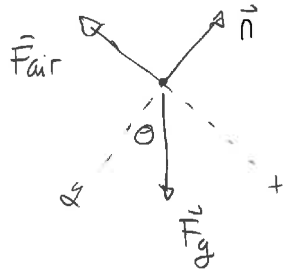
$\Rightarrow n_B = F_G - \underbrace{F_p \sin 45°}_{\text{smaller than } F_p}$

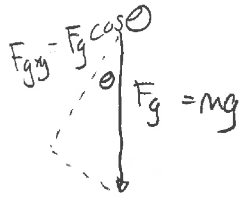
So $n_B > n_A$.

Supp Ex 39

a)







Then $\quad \sum F_x = ma_x$

$\sum F_y = ma_y = 0$

	x	y
$\vec{F}_g$	$mg\sin\theta$	$-mg\cos\theta$
$\vec{n}$	0	n
$\vec{F}_{air}$	$-150N$	0

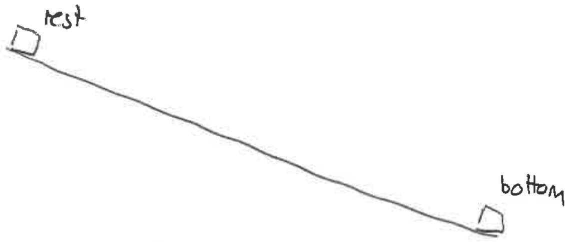
$\sum F_x = ma_x$

$\Rightarrow mg\sin\theta - 150N = ma_x$

$\Rightarrow 90kg \times 9.8m/s^2 \times \sin 15° - 150N = 90kg\ a_x$

$\Rightarrow 78N = 90kg\, a_x \Rightarrow a_x = \frac{78N}{90kg} \Rightarrow a_x = 0.87m/s^2$

b)



$t_0 = 0s \qquad t_1 =$

$X_0 = 0m \qquad x_1 = 800m$

$V_0 = 0m/s \qquad V_1 = ?$

$a_x = 0.87m/s^2$

$X_1 = \cancel{X_0} + \cancel{V_0}\Delta t + \frac{1}{2} a_x (\Delta t)^2$

$800m = \frac{1}{2} \times 0.87m/s^2 (\Delta t)^2 \Rightarrow 1840s^2 = (\Delta t)^2 \Rightarrow \Delta t = \sqrt{1840s^2} = 43s$

c) $V_1^2 = \cancel{V_0^2} + 2a\Delta X$

$V_1^2 = 2 \times 0.87m/s^2 \times 800m = 1392\ m^2/s^2 \Rightarrow V_1 = \sqrt{1392m^2/s^2} \Rightarrow V_1 = 37m/s$

Knight Ch6

Conc Q 14.

a) $F_{net} = ma$ double mass, same F $\Big\} \Rightarrow$ a is half.

Now $V_f = \cancel{V_i} + a\Delta t$

$V_f = a\Delta t \Rightarrow$ same V_f, half a $\Rightarrow \Delta t$ double

$\Rightarrow 2.0s$

b) $d = \cancel{x_i + v_i\Delta t} + \frac{1}{2}a(\Delta t)^2$

$\Rightarrow \frac{2d}{a} = \Delta t^2$

$\Rightarrow \Delta t = \sqrt{\frac{2d}{a}}$ half a means

$\Delta t \to \sqrt{\frac{2d}{a\,\frac{1}{2}}}$

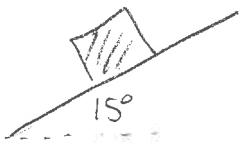
$= \sqrt{\frac{2d}{a}2}$

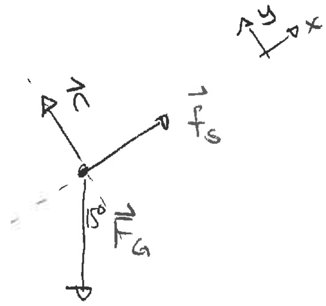
$= \sqrt{2}\,\underbrace{\sqrt{\frac{2d}{a}}}_{\text{original } \Delta t}$

Time must be $\sqrt{2}$ times original $\Rightarrow$ 1.4s

Knight Ch 6

4ed Prob 29 ~~Prob 24~~





$$\vec{F}_{net} = m\vec{a} = 0 \Rightarrow \quad \sum F_{ix} = 0 \Rightarrow f_s - F_G \sin 15^\circ = 0$$

$$\sum F_{iy} = 0 \Rightarrow n - F_G \cos 15^\circ = 0$$

$$\Rightarrow n = F_G \cos 15^\circ = mg \cos 15^\circ = 4000kg \times 9.8 \times \cos 15^\circ = 3.8 \times 10^4 N$$

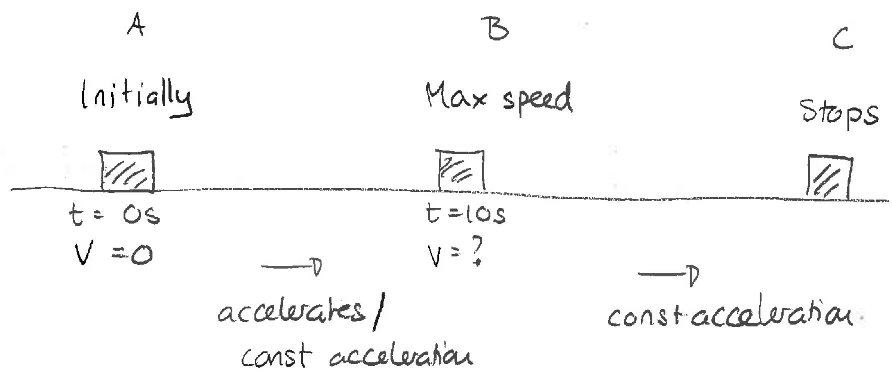
Also $f_s = F_G \sin 15^\circ = mg \sin 15^\circ$

$$= 4000kg \times 9.8m/s^2 \times \sin 15^\circ = 1.0 \times 10^4 N$$

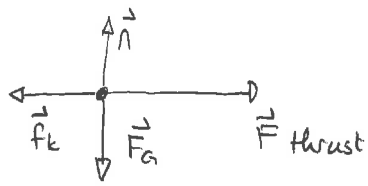
Clearly $f_s \leq \mu_s n$

Knight Ch6

4^{ed} Prob 49



a) From A to B



$\vec{F}_{net} = m\vec{a}$ but $\vec{a} = a_x\hat{i} + \cancel{a_y}\hat{j}$ $a_y = 0\,m/s^2$

$\Rightarrow$ $F_{net\,x} = ma_x$

$F_{net\,y} = 0$

Components

	x	y
$\vec{n}$	0	n
$\vec{F}_G$	0	$-mg$
$\vec{f}_k$	$-\mu_k n$	0
$\vec{F}_G$	200N	0
$\vec{F}_{net}$	ma_x	0

$F_{net\,y} = 0 \Rightarrow n - mg = 0 \Rightarrow n = mg$

$F_{net\,x} = ma_x \Rightarrow -\mu_k n + 200N = ma_x$

$\Rightarrow -\mu_k mg + 200N = ma_x$

$\Rightarrow a_x = \dfrac{200N}{m} - \mu_k g = \dfrac{200N}{75kg} - 0.10 \times 9.8\,m/s^2$

$$= 1.69 m/s^2$$

Now use kinematics.

$t_1 = 0s$ $\quad t_2 = 10s$ $\quad t_3 =$

$x_1 = 0m$ $\quad x_2 =$ $\quad x_3 =$

$v_1 = 0m/s$ $\quad v_2 = 16.9m/s$ $\quad v_3 = 0m/s$

$$v_2 = v_1 + a\Delta t$$

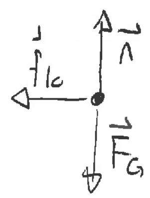
$$v_2 = 0m/s + 1.69m/s^2 \times 10s$$
$$= 16.9m/s$$

b) We can use kinematics to get x_2. We would then have to use dynamics to get the acceleration in the second period.

First x_2:

$$x_2 = \overset{0}{\cancel{x_1}} + \overset{0}{\cancel{v_1}}\Delta t + \tfrac{1}{2}a\Delta t^2 = \tfrac{1}{2} \times 1.69m/s^2 \times (10s)^2$$
$$= 84.5m$$

Then we need acceleration in the second period



$$\vec{F}_{net} = m\vec{a}$$

Clearly again $\underset{mg}{F_G} = n$ and so

$$\vec{F}_{net} = -f_k\hat{j} = -\mu_k n\hat{j} = -\mu_k mg\hat{j}.\ \text{So}$$

$$-\mu_k \cancel{m}g = \cancel{m}a \Rightarrow a = -\mu_k g = -0.10 \times 9.8m/s^2$$
$$= -0.98m/s^2$$

Now use kinematics to get x_3: Let $\Delta x = x_3 - x_2$. Then

$$v_3^2 = v_2^2 + 2a\Delta x \Rightarrow \frac{v_3^2 - v_2^2}{2a} = \Delta x$$

$$\Rightarrow \Delta x = \frac{0m^2/s^2 - (16.9m/s)^2}{2(-0.98m/s^2)} = 146m$$

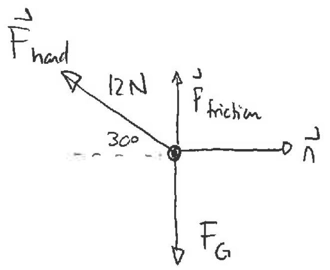
$$\Rightarrow \ \ldots$$

$X_3 - X_2 = 146m \Rightarrow \quad X_3 = X_2 + 146m$

$= 85m + 146m \quad = \quad 231m.$ $\boxed{5}$

Knight Ch6

Prob 57



There is a friction force either static or kinetic or up or down. In either case

$\sum F_x = ma_x = 0$ since no horiz motion.

$\sum F_y = ma_y$

$F_G = mg = 1.0kg \times 9.8m/s^2 = 9.8N$

	x	y
$\vec{F}_G$	0	$-9.8N$
$\vec{n}$	n	0
$\vec{F}_{hand}$	$-11N$	6N
$\vec{f}_{friction}$	0	$f_{friction}$

$F_{hand\,x} = -F_{hand}\cos 30° = -12N\cos 30°$

$= -11N$

$F_{hand\,y} = F_{hand}\sin 30° = 12N\sin 30°$

$= 6N$

Then $\sum F_y = 0 \Rightarrow \quad n - 11N = 0$

$\Rightarrow \quad n = 11N$

$\sum F_x = ma_x \Rightarrow \quad -9.8N + 6N + f_{friction} = 1.0kg\, a_x$

$\Rightarrow \quad -3.8N + f_{friction} = 1.0kg\, a_x.$

If at rest, then $f_{friction} = 3.8N$. This would be static friction and would be attained if it is less that $f_{s\,max} = \mu_s n = 0.50 \times 11N = 5.5N$

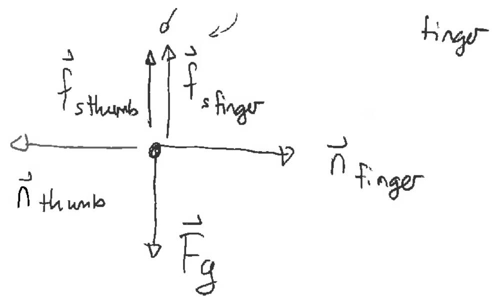
wood on wood.

This is more than the required friction It will stay at rest

Knight Ch6

4ed Prob 58

static friction from thumb + finger



$\sum F_x = ma_x = 0$

$\sum F_y = ma_y = 0.$

Now $f_{s\,thumb} \leq \mu_s n_{thumb}$

$= 0.80 \times 6.0N$

$\Rightarrow f_{s\,thumb} \leq 4.8N$

Similarly $f_{s\,finger} \leq 4.8N$

Then $\sum F_y = 0 \Rightarrow f_{s\,thumb} + f_{s\,finger} - mg = 0$

$\Rightarrow mg = f_{s\,thumb} + f_{s\,finger}$

$\Rightarrow M \times 9.8m/s^2 \leq 4.8N + 4.8N$

$\Rightarrow M \leq \dfrac{9.6N}{9.8m/s^2} \Rightarrow M \leq 0.98kg$